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Structural transformation and the oil price ☆

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ABSTRACT

What part of the high oil price can be explained by structural transformation in the developing world? Will continued structural transformation in these countries result in a permanently higher oil price? To address these issues I identify an inverted-U shaped relationship in the data between aggregate oil intensity and the extent of structural transformation: countries in the middle stages of transition spend the highest fraction of their income on oil. I construct and calibrate a multi-sector, multi-country, general equilibrium growth model that accounts for this fact by generating an endogenously falling aggregate elasticity of substitution between oil and non-oil inputs. The model is used to measure and isolate the impact of changing sectoral composition in the developing world on global oil demand and the oil price in the OECD. I find that structural transformation in non-OECD countries accounts for up to 53% of the oil price increase in the OECD between 1970 and 2010. However, the impact of structural transformation is temporary. Continued structural transformation induces falling oil intensity and an easing of the upward pressure on the oil price. Since a standard one-sector growth model misses this non-linearity, to understand the impact of growth on the oil price, it is necessary to take a more disaggregated view than is standard in macroeconomics.

1. Introduction

The average real oil price between 1970–2010 was 40.46 USD, approximately 2.79 times higher than the oil price in the forty one years preceding 1970. At the same time, world employment share in agriculture fell from 56% in 1970 to 34% in 2010 (ILO, 2003), largely driven by the spectacular industrialization of China and India.[1] While this type of correlation is appealing, it is not indicative of the role of structural transformation in developing nations on the oil price. In fact many other factors (such as the oil shocks in the 1970s) have undoubtedly also played a large role in driving the oil price over

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[1] Agricultural employment share in China/India declined from 78% of the labor force in 1970 to 45% in 2010. Given China and India's share in the world's total labor force is approximately 40% over the period, if Chinese/Indian agricultural employment share had remained at 78%, world employment share in agriculture would only have fallen to 47%. Thus 60% of the decline in world agricultural employment was driven by China and India.

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the period and one should be cautious about drawing conclusions from correlations. Nonetheless, the above observation prompts several questions. What part of the higher oil price has been driven by structural transformation in developing countries? How would the oil price have evolved if developing nations had not began the industrialization process? Finally, will continued structural transformation in these countries contribute to a permanently higher oil price?

My answer to the above questions is based on a hitherto unknown inverted-U shaped relationship in a panel of cross-country data between aggregate oil intensity and the extent of structural transformation. I find that countries in the middle stages of transition have the highest oil intensity: they spend a higher fraction of their income on oil than countries at the beginning or end of transition. If developing nations follow this pattern, their demand for oil is likely to increase initially as they industrialize and their economy becomes more oil intensive. This process should exert an upward pressure on the oil price. However, as their industrialization process comes to a close and their oil intensity begins to drop, their demand for oil should ease and the pressure on the oil price should also decline. The large size of the developing world suggests that this process may have a significant impact on the price of oil.

A decomposition of aggregate oil intensity data reveals why countries exhibit high oil intensity in the middle stages of industrialization. First, sector-specific oil intensities do not remain constant with structural transformation. In agriculture, oil intensity increases as structural transformation progresses, but in industry and services, it falls. When agriculture dominates the economy in the early stages of structural transformation, the rising oil intensity of the agricultural sector drives rising aggregate oil intensity. When non-agricultural sectors begin to dominate the economy at later stages of structural transformation, the falling intensity in industry and services drives falling aggregate oil intensity. Second, independent of the stage of structural transformation, oil intensity in agriculture and services tends to be low, whilst the oil intensity of industry tends to be high. The shift in the composition of an economy from one dominated by a low intensity sector (agriculture) to a high intensity sector (industry) and then back to a low intensity sector (services), will also contribute to an aggregate oil intensity curve shaped like an inverted-U.

To measure and isolate the impact of industrialization on the oil price, I construct and calibrate a multi-sector, multi-country growth model of structural transformation and compare it with the outcomes from a standard one-sector model. This allows me to disentangle the effect of an industrialization from other drivers of the oil price – such as changes in GDP, population, energy efficiency or oil reserve growth rates. The multi-sector model is similar to Echevarria (1997), Duarte and Restuccia (2010), Gollin et al. (2002) and Dekle and Vandenbroucke (2011) but allows for international trade and includes oil as an intermediate input. It is designed to replicate the process of structural transformation and changing sectoral oil intensities observed in the data. Structural transformation is driven by two standard channels: income effects arising from non-homothetic preferences as in Kongsamut et al. (2001) and substitution effects due to unbalanced productivity growth across sectors as in Ngai and Pissarides (2007). Changing sectoral intensities are generated by income effects and elasticities of substitution between oil and non-oil inputs in production that are different from 1.

Since different sectors may potentially vary with respect to elasticities of substitution between oil and non-oil inputs, the changing composition of an economy will affect the resulting aggregate elasticity. The multi-sector framework thus naturally generates an endogenously changing elasticity between oil and non-oil inputs. If, as the data suggest, agriculture is assumed to have a high enough elasticity and non-agriculture a low enough elasticity, a change in the structure of the economy induces aggregate elasticity of substitution to fall from above to below one, generating an inverted-U shaped aggregate oil intensity and contributing to a hump-shaped oil price path. By contrast, in a one-sector model with a standard CES production technology, aggregate elasticity of substitution between oil and non-oil inputs remains constant and aggregate oil intensity is (log) linear.

I find that structural transformation in developing countries – here taken to be all non-OECD countries – accounts for up to 53% of the increase in the oil price in the OECD over the 1970–2010 period. If emerging economies had not structurally transformed at the speed they did, the oil price in the OECD in 2010 would be 33% lower. Furthermore, the upward price pressure from structural transformation in the non-OECD should continue for the coming years. Importantly, this is *not* a permanent effect and should pass as industrialization in developing nations comes to a close. In the long run, structural transformation in non-OECD nations can actually contribute to an oil price that rises at a slower rate than industrialization had not occurred. This prediction is in stark contrast to the outcome of a standard one-sector growth model. In general, these types of models cannot replicate an inverted-U aggregate oil intensity and consequently miss this important non-linearity in the evolution of the oil price. As such, the qualitative takeaway from this paper is that in order to understand the impact of growth on the oil price, it is necessary to take a more disaggregated view than is standard in macroeconomics.

These results are important to both importers and exporters of natural resources. Long lasting changes in the oil price influence the value of oil windfalls in resource exporting countries and in turn impact government revenues, real exchange rates, GDP growth rates and welfare in those countries through changes in resource rents, Dutch Disease or the various channels of the "resource curse" (see, for example, van der Ploeg, 2010). Sustained changes in the oil price can also have a large impact on welfare or GDP growth in oil importing countries, since oil is a crucial input in production. See, for instance, the literature on oil price shocks and their impact on the macro-economy such as Hamilton (1983), Mork (1989) or Blanchard and Gali (2010) The aim of this paper, however, is not to measure the impact of changing oil prices on countries, but rather to investigate the source, and quantify the magnitude, of one particular transmission mechanism through which the large structural transformation in the developing world affects economies in the developed world.

Section 2 establishes the facts with respect to oil markets, industrialization in the developing world and the shape of aggregate oil intensity. Sections 3 and 4 describe and calibrate the model. Sections 5–7 present the quantitative predictions